INERTIA EFFECT ON 4" ALARM VALVE

BY

F. BOWER

C. HILL

ARMOUR INSTITUTE OF TECHNOLOGY

1916

20

INERTIA EFFECT ON 4" ALARM VALVE

by

FLOYD BOWER

and

CLAUDE HILL

A thesis
presented
to the
PRESIDENT and FACULTY
of
ARMOUR INSTITUTE OF TECHNOLOGY
for the degree of
Bachelor of Science in Fire protection Engineering
having completed the prescribed course of study in
Fire Protection Engineering

1916.

H M Raymond

TABLE OF CONTENTS.

page

Introduction....................................1

Definitions and notes on test conditions.............3

Description of apparatus............................11

Test methods......................................22

Calibration of apparatus............................29

Test results......................................33

Data...36

CURVES

Flexibility of stand-pipe...........................30

Calibration of nozzles............................32

Inertia affect (75# service pressure)................34

Inertia affect (55# service pressure)................35

LIST OF ILLUSTRATIONS.

title page

Diagram of apparatus with inertia #1....................12

Piping of inertia #2....................................15

Grinnell straightway alarm valve........................17

INTRODUCTION.

The object of this thesis is to demonstrate experimentally that the characteristic action of an alarm valve is affected by a change in the size and shape of the supply pipe to which it is connected.

The action of a valve can be represented by a curve. If the characteristic curve of the action of the valve in a certain installation, does not coincide with the characteristic curve of the valve in another installation in which only the shape and size of the supply pipe are different , then it must be assumed that this difference of installation causes the difference in the curves.Data for the plotting of curves is

taken with the valve in a certain installation; the supply line is then changed and a similar set of data obtained. This will give sufficient data to make the desired demonstration.

DEFINITIONS and NOTES ON TEST CONDITIONS.

In attacking the general problem of experimental study of alarm valves without precedent for guidance it has been necessary first of all to gain recognition of the several variable characteristics of wet pipe systems which may influence the performance of the valves; secondly, to devise and define units of a practical character in terms of which these variable properties of sprinkler systems may be measured;and finally to devise a testing equipment capable of producing these variable service conditions and of continuously indicating their magnitudes while tests are under way in order that each influencing condition may be at all times under control of the experimenter.Certain of the terms

used on the following pages have been arbitrarily appropriated and assigned to ~~assigned~~ a special significance for the purposes of this investigation, and lack of familiarity with the special definitions assigned to them would doubtless render unintelligible the portions of the following text in which they are employed. The factors which with our present knowledge of the subject must be considered as variable conditions having an influence upon valve performance may be listed as follows:-

1.- Service Pressure

2.- Flexibility,or compressibility of the air entrapped at the top of the riser,and and in the cross-mains and branches at the various sprinklered levels.

3.- Rate of flow from , or magnitude of demand upon , the system supplied through the alarm valve. This has relation to the number of sprinklers which, for the purpose of any individual trial of the valve under test , may be assumed as having opened to control a fire. When given comparatively small values it may represent leakage from pipe joints,sprinklers,at seats of drain valves , and at stuffing boxes of cut-off valves.

The items of valve performance which must be considered at the start as unknown quantities to

be determined by test, and as variables unless proved otherwise by test results , may be grouped as follows:-

1.- Retarding factor , or delay in sending alarm which is traceable to characteristics of the valve.

2.- Sensitiveness , or magnitude of demand upon the system for delivery of water which must be established in order to compel the valve to send alarm.

The terms which have been specially defined and are used in the senses indicated by these definitions in the text following are as follows:-

<u>FLEXIBILITY:-</u> Expressed in gallons of water.

The flexibility of a sprinkler system at any stated pressure is defined as the number of gallons of water which must be withdrawn at the system drain , when the main supply gate is closed , in order to cause 10 lbs. reduction of pressure at this point. It is assumed , and is approximately true, that replacement of the quantity of water so withdrawn would raise the pressure at the base of the riser to its original value.

<u>NOTE:-</u> The flexibility of any single equipment may vary during its life , due to (a) leakage at points which remain dry for for a time after the system is placed in service and which become tight when the air pockets are exhausted and water reached the leaks; (b) gradual

absorption of air by solution in the water which compresses it. (c) opening of sprinklers , which discharge some ar all of the air entrapped in their own branches and crossmain and are replaced by shutting off only the crossmain afterwards and replacing the head without disturbing the rest of the system;(d) occasional opening of drain valves at various levels for inspectors' tests of alarm devices , etc.

Equipments differ widely from each other in flexibility , depending not only upon their size or aggregate number of heads but also to a marked degree upon the height of the building served.

Flexibility has a very conspicuous influence upon the performance of certain alarm valves,especially

those of the differential check type, and is a quantity which must be regarded as varying over a considerable range of values in a bread view of the service requirements which alarm valves must meet.

RETARDING FACTOR:- Expressed in seconds of time. The retarding factor of an alarm valve is defined as the number of seconds elapsing, while a constant rate of flow of water is being drawn out of the system above the valve, between the first movement of water from the supply upward through the valve and the moment when the valve has completed the mechanical movement or movements necessary to cause an alarm.

NOTE:- A common error in determining time delay in the field is introduced by count-

ing time from the moment a sprinkler or test valve is opened until an alarm is sounded.

SENSITIVENESS:- Expressed in gallons of water flowing per minute. The sensitiveness of an alarm valve is defined as the minimum rate of flow which , if continuously drawn from the system above the valve, and entirely irrespective of time delay , will compel the valve to send alarm.

INERTIA:- Unit not defined.

The term inertia as used here refers to the inertia of the water flowing in the supply pipe between the source of supply and alarm valve. This quantity depends upon the shape and size of the supply line. The different inertias used are most easily denoted by a description of the different supply pipes.

DESCRIPTION OF APPARATUS.

The apparatus used in the performance of this thesis is as follows.

(A) is a calibrated 4500 gal. tank having connections from a 50 ft. air pump, and a 550 gal. Quimby water pump. A 6" pipe leads from the bottom of the tank through the gate B and thence around to the 4" upright pipe , supplied with a gate D, in which the valve (E) to be tested , is installed. The path of the system supply water from the 4" pipe from the 4500 gal. tank continues from the valve (E) through the gate (G) up into the 6" stand pipe (O). An accurate 10" gage is tapped in at (C),thus, at all times,registering the service pressure. (F)

is a 36" differential mercury gauge , the two legs being tapped into the system near the valve to be tested , but on opposite sides of the check . From this gage, readings of the differential of the valve are obtained . (J) is the calibrated nozzle, tapped into the system at the base of the 6" stand pipe (O) as shown; (H) is the controlling valve for the nozzle , and (I) is the calibrated gage which registers the pressure at which the flow is taking place through the nozzle, and from which reading the rate of flow is obtained. (N) is a 3/4 " pipe tapped in at the stand-pipe top, by which air is drawn off or the stand-pipe vented through the globe valve (M). ¶(L) is an is an 84" differential mercury gage , one leg of which is tapped in at the base of the standpipe and the other leg

tapped in at the top through the 3/4 " pipe (N). Thus the difference in levels of the two mercury columns in L is a measure of the gravity head of water in the stand-pipe as shown , and which at all times accurately registers the system pressure.

Inertia #1 is represented by the pipe extending from the tank (A) to the valve (E). Another supply is connected to the valve (E) at the point (Q). The details of this supply are shown on plate 3.The pressure tank (Z) is connected to a 50 ft. air pump which is provided with a remote control, and also to a 550 gal. Quimby pump. The piping between the pressure tank (Z) and the valve (E) represents inertia #2.

The alarm valve (E) used in making these tests is the Grinnell alarm valve (4").

Fig. 1 shows an alarm valve installation of type used in this test. The 3' mercury gage was tapped into the system in place of the two Bourdon type gages shown in the cut. In the experimental installation used, the pipe (P) leading to the water motor alarm was plugged shut. The electric alarm (M) was connected to the electric lighting circuit through an incandescent lamp.

The details of the valve are shown in fig.2. The main check consists of a flat brass disc,(3) pivoted at a point (5) back of the disc as is shown on the figure. The disc is pivoted by means of a brass strap (4) drilled at each end to accomedate the pivot bolt (5) and a stud bolt through the valve and strap.A flat ,soft rubber

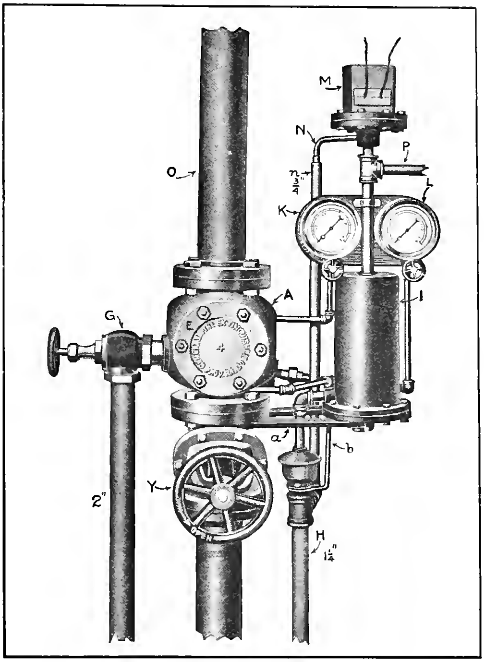


FIG. 1.

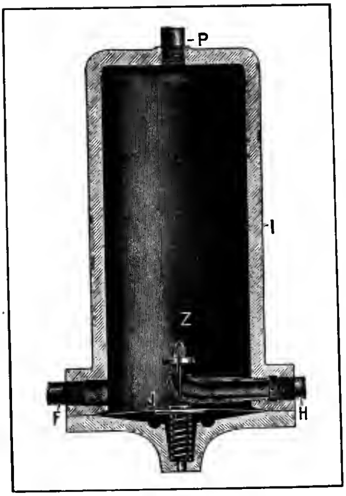


FIG. 3.

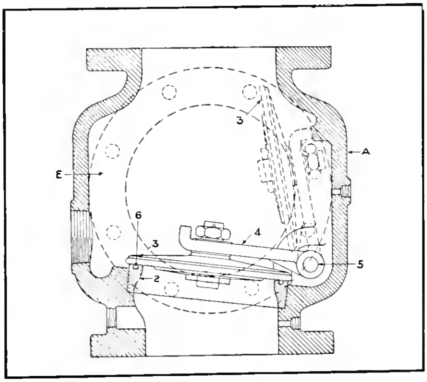


FIG. 2.

Page 17

ring of the same daameter as the main check is held against the check by a four-inch washer which is held in position by a nut turned up on the bolt through the check.

The check seats on a brass ring seat having an internal diameter of 4 inches and having a total width of approximately 9/16". A groove (6) 3/16" wide by approximately 1/4" deep is machined in the ring seat , theinner edge of the ring groove lying 3/16" from the inner edge of the seat.This groove communicates with the retarding chamber (I) fig. 1 through a 3/8 " orifice and a 1/2 " pipe (F) fig.3. When the check is on its seat, the groove is vented to the atmosphere through the retarding chamber and similarly when the check is off its seat a passage for the water from the valve to the retarding chamb-

er is created by the groove and pipe F.

The details of the retarding chamber are shown in fig. 3.F is a pipe leading from the groove in the seat ring to the retarding chamber. (P) is a pipe leading to the alarm device shown at (M) fig. 1.The pipe (H) leads to waste but is closed by the valve (Z) when the weight of water in the retarding chamber forces the diaphram (J) downward.

The electric alarm (M) consists of a knife switch so mounted that the pressure of the water flowing to waste through the pipe (N) will force a diaphram at the base of M upward thereby closing the knife switch and sending alarm.

OPERATION OF THE VALVE.

The valve has a differential action due to

the vented groove in the seat ring. Consequently the check will remain closed until the pressure above the check has reached a value sufficiently lower than the pressure below , when the valve will open. Consider the system to be in operating condition,i.e. the check is on the seat and the pressure above the check is equal to or perhaps a little in excess of the pressure below. Next consider that a sprinkler head has opened and that water is being drawn off from above the check.This flow continues until the pressure above the check has become reduced to such a point that the check opens due to the constant service pressure below. The groove in the seat ring which had been vented to the atmosphere while the check was on its seat is now subjected to the

existing water service pressure. A flow is established to the retarding chamber through the groove(6) and the pipe (F).The pressure builds up in the retarding chamber until the electrical circuit or water motor , or both are actuated to give an alarm.

Under certain conditions it has been found that the valve does not turn in an alarm for one opening of the check. In this case , water must be drawn from above the check in such volume that the check will again open before the water in the retarding chamber from the previous opening of the check , has had time to drain off. In this way the pressure in the retarding chamber increases a little with each opening of the check until finally the alarm mechanism are actuated.

TEST METHODS.

The purpose of the operating tests about to be described is to determine the effect on the action of the valve of changing the inertia.

A curve showing the relation between flexibility and sensitiveness represents the characteristic action of the valve. Data for the flexibility sensitiveness curve ,with constant service pressure, is taken , first with inertia #1 then with inertia #2. When inertia #1 is used valve W is kept closed and valve B Open.When inertia #2 is used, valve W is kept open and valve B closed. The difference between the curves thus obtained is due to the inertia affect.

The tests were conducted as follows:-

The valve to be tested is installed in an upright 4" pipe connecting with the 6" horizontal piping shown at (E). Plate II attached hereto. A very liberal air cushion is maintained in the pressure tank which supplies the valve and system to facilitate maintenance of constant pressure when water is being drawn from the system. When the system is being supplied through the piping of inertia #1, the pressure of the pressure tank is maintained constant by opening a valve in a pipe connecting the pressure tank with a high pressure air tank, when ever the pressure of the pressure tank falls appreciably. When the system is being supplied through the piping of inertia #2, the pressure of the pressure tank is maintained constant by means of a 50 ft.

air pump connectec to the pressure tank and controlled by a snap wsitch near the alarm valve.The main-gate is opened quickly to permit water to rush into the system at high velocity , thus avoiding retention of air pockets in the horizontal portion . The main-gate is then closed and the standpipe water level drawn down to about 8 or 10 ft. above the point (P).

The 1/4" stand-pipe vent cock is now closed and air introduced into the standpipe from the air pump until the pressure in the stand-pipe is from 3 lbs. to 5 lbs. in excess of the service pressure. This pressure is noted on the accurately calibrated 0-150 lb. Crosby gage at (K). The pressure in the supply tank is now raised to approximately the same pressure an exists in the stand-pipe , and the main-

gate (D) is opened. Unless , otherwise stated , the gates (B) and (G) are always open. The system is allowed to stand a few minutes until conditions become settled and water is then drained off from a point above theo check in the alarm valve, until the desired pressure is obtained as noted on gage (K).The system is again allowed to stand and the gages noted to make sure that all valves are tight. When conditions have become settled and the pressure as noted on gage (K) is exactly what is desired , a reading of the 84 " differential mercury gage(L) is carefully taken and tabulated for determination of the stand-pipe water level , from which the flexibility of the system is later computed.

One man is now stationed at the regulating

valve (H) controlling the calibrated nozzle (J) and another man , supplied with a stop watch takes a position near the valve and directly in front of the 3' mercury gage (F). A flow at which an alarm will be given is established , and kept constant by the man at the nozzle.

After an alarm has been given the flow is stopped, the system is again brought to exactly the same conditions as existed before the fow was started. After the adjustment the system is allowed to come to rest and again adjusted if nedessary, and a smaller flow is taken from the system through the nozzle (J). This is continued until the least rate of flow at which an alarm will be given, is determined.As matter of incidental interest, the man at the valve

obtains data on differential of the valve as noted by the 3' mercury gage , and also by means of the stop watch obtains the period of time which the check remains on its seat , the period that the check is off its seat and the retarding factor.

Air is next drawn from the stand-pipe through the vent cock (M) until the feet head of water in the stand-pipe has increased from 4 to 6 feet. Water introduced by the pump until the pressure is a little in excess of the pressure desired , the system is allowed to come to rest and water drained off as before until the same pressure as in previous test is reached. The conditions are again allowed to become settled , re-adjusting if necessary , the 84 " gage is read , and the least rate of flow at which an alarm will be given, together with the

attendant data is again obtained. This procedure is repeated with various values of flexibility up to the limit of the stand-pipe.

The data thus obtained is figured out in terms of flexibility and sensitiveness i.e. rate of flow at each point taken, by means of calibration curves described elsewhere. A curve is now drawn plotting flexibility against sensitiveness. A similar procedure is followed in order to obtain curves at the remaining pressures and inertias.

Note. Tests were made with 75 and 55 lbs. service pressure.It was found that with a service pressure of 35 lbs. the highest rate of flow that could be attained by the apparatus used was not sufficient to give an alarm, at any flexibility of the stand-pipe.

CALIBRATION OF APPARATUS.

GAGES:-

The 10 inch 0-150 lb. Crosby Spring gage was accuzately tested by means of a Crosby Oil Tester. The position of the needle of the gage, when tested by the Crosby Tester, for the several pressures at which it was , almost exclusively used namely 65 and 75 lbs. was marked on the dial of the gage. These marks were checked several times and were found to be correct each time.The 30 lb. gage used on the calibrated nozzle was calibrated at the start of each days run.The data on the calibration is found on a following page.

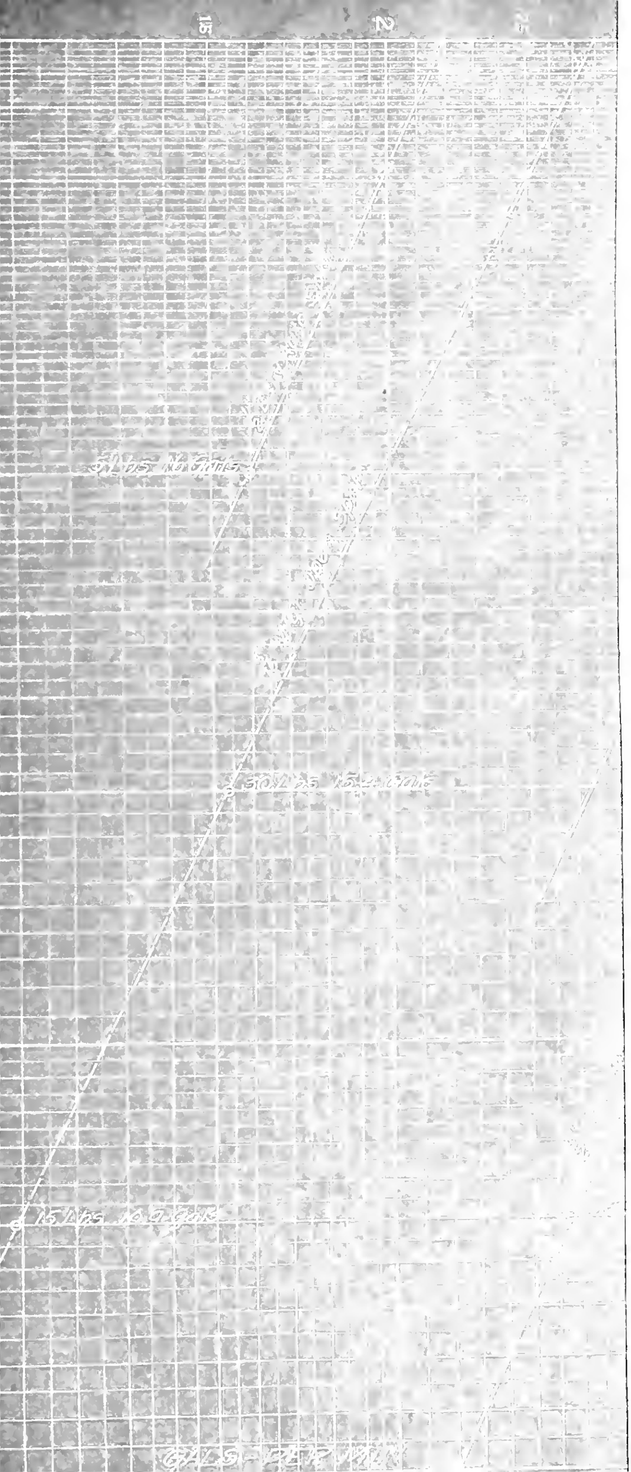
FLEXIBILITY OF 6 " STAND PIPE:-

The stand-pipe used in these tests had been calibrated as to its flexibility by the engineers of the Underwriter's laboratories.The

calibration curves plotted by them were used in determining the flexibility of the standpipe.The calibration curve is found on a following page.

NOZZLE CALIBRATION:-

Three different sized nozzles were used in these tests. The calibration curves of these nozzles as plotted by the Laboratorie's engineers is found on a following page.



Part 32

TEST RESULTS.

The curves obtained show a very marked inertia effect. The shape of the curve as well as the quantities represented are influenced by a change of inertia.

The most noticeable feature of the curves is increase in the sensitiveness of the valve with an increase of length of supply pipe. We have attempted to analyze the forces acting on the valve but have been unable to reach any satisfactory explanation of the affect noticed.

The data taken on the retarding factor and length of period check was off seat seem to be too erratic to be of any special significance.

Page 34

Page 35

Page 36

SERVICE PRESSURE #2 — INERTIA #1

Page 38

SERVICE PRESSURE 75# – INERTIA #2.

TIME